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# मानक

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IS 7916 (1992): Open power channels - Code of practice [WRD  
14: Water Conductor Systems]



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भारतीय मानक

खुली पावर वाले चैनल – रीति संहिता

( पहला पुनरीक्षण )

*Indian Standard*

OPEN POWER CHANNELS – CODE OF  
PRACTICE

( *First Revision* )

UDC 627.841

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BUREAU OF INDIAN STANDARDS  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Water Conductor Systems Sectional Committee had been approved by the River Valley Division Council.

This standard was first published in 1975. This revision has been taken up in the light of experience gained during the last few years in the use of this standard.

The salient features of this revision are as under:

- a) Provision of 25 percent extra freeboard to be taken at the time of design of cross section of power channels as due to passage of time the freeboard originally kept gets encroached and also due to deposit of silt in the bed during the lean discharge period, the carrying capacity of the power channel gets reduced;
- b) Provision of some arrangements so as to facilitate grouting behind concrete lining as due to wave action in the power channel, the drainage material behind the lining gets sucked and hollowness is created on the back of the lining;
- c) Provision of crest at the outlet to control the rate of drawdown has been deleted;
- d) Provision for wave suppressors in the head reach for dissipation of energy; and
- e) Optimum design of power channels carrying considerable sediment.

# *Indian Standard*

## OPEN POWER CHANNELS — CODE OF PRACTICE

( *First Revision* )

### 1 SCOPE

This standard covers planning, layout, design, construction and maintenance of open power channels meant to serve as water conductor system for a hydro-electric power project.

### 2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

### 3 TERMINOLOGY

**3.0** For the purpose of this standard, the definitions given in IS 4410 ( Part 5 ) : 1982 and the following shall apply.

#### 3.1 Surges

Surges are a class of hydraulic transients in water conductor systems in which variations of flow and pressure occur when one steady state changes into another steady state due to rejection and/or acceptance of load on hydro-power station units. In power channels surges cause sudden changes in water level which have to be taken into account in design.

#### 3.2 Drawdown

It is the extent of fluctuation of water levels in the channel, the volume of water contained therein being used as pondage for peaking purposes.

### 4 PLANNING AND LAYOUT

#### 4.1 Planning

A prerequisite in the planning of power channel is to fix the discharge capacity. The discharge capacity should be fixed based on the water power studies to be made for arriving at the installed capacity of the power plant. These studies include the flow duration curve and mass curve for available discharge or storage capacity of reservoir and extent of balancing storage/pondage requirements to be provided

at suitable points of water conductor system to suit the load demand and type of operation of power station ( namely, peaking station, base load station, etc ). In case of stage development of the project, the capacity of the channel may have to be fixed for the ultimate stage of power development as permissible by economic studies.

#### 4.2 Layout

For designing the layout reference may be made to IS 5968 : 1987. While it is desirable to fix the take-off at the highest elevation possible for obtaining maximum head for power generation, topographical and geological features of the terrain should be kept in view while planning the alignment of power channel with sufficient care taken to avoid continuous high embankments.

#### 4.3 Data Required

The following data are required for planning and layout of open power channels:

- a) Topographical map of the area;
- b) Sub-surface data of soil characteristics including mechanical properties and shear parameters; in case the sub-grade is in rock, data regarding the structure and fabric of the rock, depth and degree of rock strata variation, effect of weathering and data regarding stability of rock and earth slopes;
- c) Texture and composition of soil;
- d) Permeability of sub-grade strata in relation to seepage loss and for design of filters;
- e) Water availability;
- f) Sub-soil water level, annual fluctuations in its levels in the area and quality of sub-soil water;
- g) Drainage facilities of the area including possibility of water logging and salination;

- h) Quantity and gradation of sediment load expected in the power channel;
- j) Permissible sediment grade through water turbines;
- k) Discharge requirements of irrigation system, if the channel has to cater for irrigation also;
- m) Power demand and load curve of the area and future extension of power demand;
- n) Seismicity of the region and value of ground acceleration;
- p) Availability of suitable construction materials, including filter materials for proposed drainage system under lining; and
- q) Existing communication and transport facilities.

**4.4** Adequate investigations should be carried out to collect data indicated in 4.3 in all respects.

**4.5** For general guidance regarding suitability of soil for use in power channel embankment, reference may be made to IS 1498 : 1970 and IS 4701 : 1982.

## 5 DESIGN

### 5.1 General

Power channel design is determined by the type of operation. The following three types of operation are normally adopted:

- a) Constant discharge in channel and constant water levels upstream and downstream with bypass arrangements from upstream to downstream;
- b) Channels with balancing reservoir to take care of diurnal fluctuations. This will in many cases result in reduced capacity requirements of the channel upstream of the reservoir; and
- c) Lock operation of channel, in which the channel is used similar to a lock and the discharges in channel fluctuate with the load of the generating stations.

### 5.2 Design of Cross Section

The cross section of power channel, bed slope, etc., are designed on the basis of economic studies considering the optimum cost of construction and cost of energy lost due to head loss in friction. Also, the side slopes of the channel section should be designed to suit the drawdown conditions in the power channel given in 5.4. For designing the channel section reference may be made to IS 7112 : 1973 and

IS 10430 : 1982. For power channels carrying water to the power house the phenomenon of surges due to variation of discharge on account of load demand or rejection should be analyzed fully. Sufficient freeboard should be provided to avoid overtopping of water on channel sides which may endanger the channel section. At the time of design of cross section about 25 percent extra freeboard may be provided to avoid reduction in power generation in subsequent years. Depending upon the topography, provision of suitable spillover or balancing reservoir of sufficient capacity to act as an open surge basin at forebay may be considered.

**5.2.1** Factors involved in the analysis of surge phenomenon are as follows:

- a) Hydraulic section, slope of the channel and velocity of flow in the channel;
- b) Amount of load rejection or load acceptance;
- c) Rate of closure of units or acceptance of load; and
- d) Size of forebay or surge basin on the channel.

**5.2.2** Criteria for analysis of the maximum and minimum surges in power channel should be the same as for the surge in head race tunnels. Maximum surge height in a power channel due to load rejection may be calculated from the empirical formulae given below:

- a) For abrupt closure  $h_{max} = \sqrt{K^2 + 2Kh}$
- b) For gradual closure within the period required for the first wave to travel twice the length of the channel:

$$h_{max} = \frac{K}{2} + V \sqrt{h/g}$$

where

$h_{max}$  = maximum surge wave height,

$K = V^2/2g$  = velocity head,

$V$  = mean velocity of flow, and

$h$  = effective depth =  $\frac{\text{area of cross section}}{\text{top width}}$

**5.2.3** When the power channel is part of a water conductor system including tunnels, hydraulic transient conditions for the whole system should be studied for load variations of the power units.

### 5.3 Lining for Power Channel

Power channel should preferably be lined since:

- a) It is hydraulically more efficient thus ensuring smaller cross section, relatively

flatter slope for the same discharge capacity resulting in economy;

- b) Loss of water due to seepage or leakage is minimized;
- c) Closure of power channel for repairs, if any, are remote and also they would be of short duration only thus interrupting power generation for brief periods only;
- d) Cost of operation and maintenance is lower;
- e) Weed growth is minimized; and
- f) Some suitable arrangements be provided originally on cement concrete panels to enable facilitate sand grouting behind concrete linings. Sand grouting is essential to avoid settlement of cement concrete.

### 5.3.1 Construction of Lining

The type of lining to be provided in the power channel depends on the field conditions. For selection of the type of lining reference may be made to IS 10430 : 1982. For construction of lining reference may be made to IS 3872 : 1966, IS 3873 : 1992, IS 4515 : 1967, IS 7113 : 1973, IS 7873 : 1975, IS 9698 : 1980 and IS 11809 : 1986.

### 5.3.2 Under-drainage

Adequate precaution should be taken for safety of lining of the channel where the alignment is through terrain with very high ground water level and is subjected to high seasonal variations or where the soil is sufficiently impervious to prevent free draining of seepage or leakage from the channel. For this suitable under-drainage should be provided to protect the lining. Reference may be made to IS 4558 : 1983 for designing the under-drainage system for the power channels.

### 5.3.3 Drainage

In case of fluctuation of water levels due to surges and diurnal fluctuations in channel operations of types 5.1 (b) and 5.1 (c), the effect on lining should be provided for by suitable drainage system. It is preferable to utilize natural drainage to drain the system rather than a flap valve arrangement.

### 5.4 Drawdown

Depending upon the pattern of load and extent of storage provided, fluctuations occur in water level of the power channel due to utilization of balancing storage. This effect of drawdown and the rate at which it occurs govern stability of

the side slopes and lining of the channel. When such cases of excessive and rapid drawdown occur, suitable automatic control structures may have to be provided to regulate the rate of drawdown. For instance automatic gates at this outlet may be provided to control the rate of drawdown.

## 5.5 Sediment Control

Necessary desilting arrangements should be provided to remove sediment content to the degree safe for operation of generating units. The quantity of sediment that can be permitted depends on the type of turbine, its head, the size and mineralogical content of the sediment. The exact requirement should be based on the design of turbine. Upstream of desilting arrangement, the channel should be provided with extra capacity to allow for discharge required to flush out the sediment.

**5.5.1** The power channel should be so designed alongwith balancing reservoir capacity to take care of power requirements including peaking periods and control of entry of sediment beyond permissible limits.

**5.5.2** For design of sediment control devices reference may be made to IS 6004 : 1980, IS 6522 : 1972, IS 7495 : 1974, IS 7871 : 1975 and IS 7880 : 1975.

## 5.6 Head Regulator

For design of head regulator reference may be made to IS 6531 : 1972.

## 5.7 Trash Rack

Suitable trash racks should be provided at the exit end of power channel that is at the forebay portion, wherefrom the penstock offtake to avoid trash entering the penstocks which would otherwise damage parts of the generating unit.

## 5.8 Bypassing Arrangements

Provisions should be made for bypassing arrangements in the balancing reservoir or in power channels as near to the balancing reservoir as possible in the event of sudden load rejection. Also in case of very long power channels provisions may be made for escape regulators (see IS 6936 : 1973) in power channel for emptying it in case of emergency/periodical closure, if any.

## 5.9 Wave Suppressors

Provision may be made for wave suppressor in the head reach in the event of incomplete dissipation of energy upstream of power channel.



**6 MAINTENANCE**

6.1 For successful and economic operation of power plants, proper maintenance of power

channels is essential. Reference in this regard may be made to IS 4839 ( Part 1 ) : 1992, IS 4839 ( Part 2 ) : 1992 and IS 4839 ( Part 3 ) : 1992.

**ANNEX A**

( Clause 2.1 )

**LIST OF REFERRED INDIAN STANDARDS**

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
1498 : 1970	Classification and identification of soils for general engineering purposes ( <i>first revision</i> )	6522 : 1972	Criteria for design of slit vanes for sediment control in offtaking canals
3872 : 1966	Code of practice for lining of canals with burnt clay tiles	6531 : 1972	Criteria for design of canal head regulators
3873 : 1992	Code of practice for laying cement concrete and stone slab lining on canals ( <i>Second revision</i> )	6936 : 1973	Guide for location, selection and hydraulic design of canal escapes
4410 (Part 5) : 1982	Glossary of terms relating to river valley projects : Part 5 Canals ( <i>first revision</i> )	7112 : 1973	Criteria for design of cross section for unlined canals in alluvial soil
4515 : 1967	Code of practice for boulder lining for canals	7113 : 1973	Code of practice for soil cement lining for canals
4558 : 1983	Code of practice for under-drainage of lined canals ( <i>first revision</i> )	7495 : 1974	Criteria for hydraulic design of silt selective head regulator for sediment control in offtaking canals
4701 : 1982	Code of practice for earthwork on canals ( <i>first revision</i> )	7871 : 1975	Criteria for hydraulic design of groyne walls ( curved wing ) for sediment distribution at offtake points in a canal
4839	Code of practice for maintenance of canals:		
( Part 1 ) : 1992	Unlined canals ( <i>second revision</i> )	7873 : 1975	Code of practice for lime concrete lining for canals
( Part 2 ) : 1992	Lined canals ( <i>second revision</i> )		
( Part 3 ) : 1992	Canal structures, drains, outlets, jungle clearance, plantation and regulation ( <i>second revision</i> )	7880 : 1975	Criteria for hydraulic design of skimming platform for sediment control in offtaking canal
5968 : 1987	Guide for planning and layout of canal system for irrigation ( <i>first revision</i> )	9698 : 1980	Code of practice for lining of canals with polyethylene film
6004 : 1980	Criteria for hydraulic design of sediment ejector for irrigation and power channels ( <i>first revision</i> )	10430 : 1982	Criteria for design of lined canals and guidelines for selection of type of lining
		11809 : 1986	Code of practice for stone slate lining stone masonry lining for canals

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**BUREAU OF INDIAN STANDARDS**

**Headquarters:**

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002  
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha  
( Common to all Offices )

**Regional Offices :**

	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	{ 331,01 31 331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	{ 37 84 99, 37 85 61, 37 86 26, 37 85 62
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	{ 53 38 43, 53 16 40, 53 23 84
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	{ 41 24 42, 41 25 19, 41 23 15, 41 29 16,
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